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A/REISSUE

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Leonard H. Bieman

Title: SCANNING PHASE MEASURING METHOD AND SYSTEM FOR AN OBJECT AT A VISION STATION

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BOX PATENT APPLICATION
Assistant Commissioner for Patents
Washington, D.C. 20231

We are transmitting herewith the following attached items (as indicated with an "X"):

X A return postcard.
X A Communication Re: Transmittal of Reissue Application (1 Page).
X Reissue Application including Specification, Claims, Abstract and Drawings (16 pgs).
X Declaration of Inventor (Unsigned) (4 pgs).
X Offer to Surrender Original Patent (1 pg).
X Assent by Assignee under 37 C.F.R. 1.172 and Power of Attorney (2 pgs).
X Request for Title Report (1 pg).
X Request to Transfer Drawings and a copy of the drawings as printed in patent of parent application (1 pg).
X Preliminary Amendment (20 pgs).
X Small Entity Statement (1 pg).
X A check for $1233 to pay the reissue filing fee, and a check to pay the Title Report Fee.

The check for $1233 covers the small entity fee of $395 plus $123 for three excess independent claims, plus $ 715 for 65 excess total claims.
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SCANNING PHASE MEASURING METHOD AND SYSTEM FOR AN OBJECT AT A VISION STATION

CROSS-REFERENCE TO RELATED APPLICATION

This application is related to U.S. patent application entitled "Optical Measuring System" filed Jun. 17, 1994 and having U.S. Ser. No. 08/262,130.

TECHNICAL FIELD

This invention relates to non-invasive measuring methods and systems and, in particular, to scanning phase measuring methods and systems for an object at a vision station.

BACKGROUND ART

Height distribution of a surface can be obtained by projecting a light stripe pattern onto the surface and then reimaging the light pattern that appears on the surface. A powerful technique for extracting this information based on taking multiple images (3 or more) of the light pattern that appears on the surface while shifting the position (phase) of the projected light stripe pattern is referred to as phase shifting interferometry as disclosed in U.S. Pat. Nos. 4,641,972 and 4,212,073.

The multiple images are usually taken using a CCD video camera with the images being digitized and transferred to a computer where phase shift analysis, based on images being used as "buckets," converts the information to a contour map of the surface.

The techniques used to obtain the multiple images are based on methods that keep the camera and viewed surface stationary with respect to each other and moving the projected pattern.

A technique for capturing just one bucket image using a line scan camera is described in U.S. Pat. No. 4,965,665 but not enough information is available to do a phase calculation based on multiple buckets.

Other U.S. patents which show phase shifting include U.S. Pat. Nos. 5,202,749 to Pfister; 4,794,550 to Greivenkamp, Jr.; 5,069,548 to Boehnlein; and 5,307,152 to Boehnlein et al.

U.S. Pat. Nos. 5,398,113 and 5,355,221 disclose white light interferometry systems which profile surfaces of objects.

In the above-noted application, an optical measuring system is disclosed which includes a light source, gratings, lenses, and camera. A mechanical translation device moves one of the gratings in a plane parallel to a reference surface to effect a phase shift of a projected image of the grating on the contoured surface to be measured. A second mechanical translation device moves one of the lenses to effect a change in the contour interval. A first phase of the points on the contoured surface is taken, via a four-bucket algorithm, at a first contour interval. A second phase of the points is taken at a second contour interval. A control system, including a computer, determines a coarse measurement using the difference between the first and second phases. The control system further determines a fine measurement using either the first or second phase. The displacement or distance, relative to the reference plane, of each point is determined, via the control system, using the fine and coarse measurements.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a method and system including an optical head for making an optical

phase measurement of a viewed object by generating an image whose intensity varies as a function of position relative to the optical head and wherein the system is configured in a way which allows multiple images with different phase information as the viewed object is moved in a direction perpendicular to the imaging system and these multiple images are used to calculate a phase image that is proportional to the optical phenomena that creates the phase change.

Another object of the present invention is to provide a method and system including an optical head for making a phase measurement of imagable electromagnetic radiation returned to a multi-line linear detector array by setting up the optics in the optical head in a manner such that a different phase value is imaged onto each line of the detector array such that each line of the detector array creates an image with a different optical phase value for the same point on the imaged object.

Yet still another object of the present invention is to provide a method and system including an optical head for scanning the height of a surface wherein the optical head includes a light stripe projector and imaging system where the projected pattern does not move relative to the imaging system and the optical head is configured in a way which allows multiple images with different phase information as the surface is moved with respect to the imaging system and these multiple images are used to calculate a phase image that is proportional to the height of the scanned surface.

In carrying out the above objects and other objects of the present invention, a method is provided for high speed scanning phase measuring of an object at a vision station to develop physical information associated with the object. The method includes the steps of projecting a pattern of imagable electromagnetic radiation with at least one projector and moving the object relative to the at least one projector at the vision station to scan the projected pattern of electromagnetic radiation across a surface of the object to generate an imagable electromagnetic radiation signal. The method also includes the steps of receiving the imagable electromagnetic radiation signal from the surface of the object with a detector having a plurality of separate detector elements and maintaining the at least one projector and the detector in fixed relation to each other. Finally, the method includes the steps of measuring an amount of radiant energy in the received electromagnetic radiation signal wherein the detector elements produce images having different phases of the same scanned surface based on the measurement and computing phase values and amplitude values for the different phases from the images.

In one embodiment, preferably the physical information is dimensional information and the imagable electromagnetic radiation is light.

In another embodiment, preferably the physical information is polarization information, the imagable electromagnetic radiation is polarized, a response of the detector elements is polarization-sensitive and the images are based on polarization from the surface.

Further in carrying out the above objects and other objects of the present invention, a system is provided for carrying out the above method steps.

The above objects and other objects, features, and advantages of the present invention are readily apparent from the following detailed description of the best mode for carrying out the invention when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of a machine vision system including an optical head for carrying out the method and system of the present invention;

FIG. 2 is a schematic view illustrating the details of a first embodiment of the optical head of FIG. 1;

FIG. 3 is a schematic view illustrating a second embodiment of the optical head of FIG. 1 wherein a grating is introduced on the imaging side to create an optical moire pattern; and

FIG. 4 is a schematic view illustrating another embodiment of the invention wherein a pattern of polarized electromagnetic radiation is projected.

BEST MODE FOR CARRYING OUT THE INVENTION

Referring now to FIG. 1, there is illustrated schematically a machine vision system, generally indicated at 10, including an optical head, generally indicated at 12, for carrying out the method of the present invention. The method and system 12 of the present invention are provided for high speed, scanning phase measuring of an object 14 at a vision station 16 to develop dimensional information such as height information of a surface 18 of the object 14. The object 14 moves relative to the optical head 12 as indicated by arrow 20.

In general, the invention relates to the non-invasive three-dimensional measurement of surface contours using technology such as moire technology with a novel approach that allows continuous scanning of a surface. A more general adaptation of this approach allows the measurement of other optical parameters via the same scanning approach but with a different optical configuration.

The machine vision system 12 typically includes an image digitizer/frame grabber 22 electrically coupled to the optical head 12. The image digitizer/frame grabber 22 samples and digitizes the input images from an image source such as a camera contained within the optical head 12 as described in detail herein below. The frame grabber 22 places each input image into a frame buffer having picture elements. Each of the picture elements may consist of an 8-bit number representing the brightness of that spot in the image.

The system 10 also includes a system bus 26 which receives information from the image digitizer/frame grabber 22 and passes the information on to the IBM compatible host computer such as a Pentium PC 28.

The system 10 may include input/output circuits 30 to allow the system 10 to communicate with one or more external peripheral devices such as a drive 31 or robots, programmable controllers, etc. having one or more stages. The drive 31 provides relatively uniform and continuous movement between the object 14 and the head 12. The I/O circuits 30 may support a three axis stepper board (i.e. supports multiple axis control) or other motion boards.

As illustrated in FIG. 2, a camera of the optical head 12 preferably includes a solid state image sensor such as a trilinear array camera 24. For example, the camera 24 may be the Kodak CCD chip model KLI-2103 which has 3 rows of detector or sensing elements 25 each having 2098 CCD sensing elements per row. Each row is physically separated by a distance equivalent to 8 pixel elements. The camera 24 was originally designed for color scanning with a red, green, and blue color mask over each element, respectively. For the present invention, the masks are not used but rather are removed.

The system bus 26 may be either a PCI, an EISA, ISA or VL system bus or any other standard bus.

The image digitizer/frame grabber 22 may be a conventional three channel color frame grabber board such as that

manufactured by Imaging Technologies, or other frame grabber manufacturers. Alternatively, the image digitizer/frame grabber 22 may comprise a vision processor board such as made by Cognex.

The machine vision system 10 may be programmed at a mass storage unit 32 to include programs for image processing and/or image analysis, as described in greater detail hereinbelow.

A monitor 34 is also provided to display images.

Referring again to FIG. 2, generally, multiple images with different phases are obtained by moving the surface 18 of the object 14 while keeping a pattern 36 projected by a light strip projector 38 and the camera 24 stationary with respect to each other within the optical head 12. The optical head 12 (i.e. when the system 10 is a scanning moire system) has no mechanical or optical mechanism that changes the position of the projected pattern 36. To obtain multiple phase images, there is relative movement between the optical head 12 and the measured surface 18.

Although taking images with movement in any direction could result in the ability to obtain phase shifts, there is only discussed herein two specialized cases. The first case is movement of the object 14 in a direction 20 perpendicular to an optical axis of a lens 40 of the camera 24 thereby creating a camera image. The second case is movement of the object 14 in a direction parallel to the optical axis of the lens 40 thereby creating a second camera image.

As with CCD linear array scanning, the object 14 is moved in the direction 20 which is perpendicular to both the optical axis of the linear array camera lens 40 and the line of pixels in the linear array camera 24. Thus, as the linear array camera 24 is read out line by line, the image of the object 14 moving past is created row by row. Using the trilinear array camera 24 for scanning produces three images of the scanned surface 18 with each image being offset by a certain number of rows. This offset is a function of the spacing between arrays and the rate at which the image of the surface 18 is moved past the sensing elements 25.

The concept of scanning phase measuring of the present invention is analogous to the color sensing by the above-noted color trilinear array except the color filters are not present and each of the three scanning lines measures a different phase of the projected light pattern instead of the color.

In terms of phase shifting technology, each scanning line measures a different "bucket," and a three "bucket" algorithm is used on the computer 28 for measuring the phase of the projected light pattern and this phase is proportional to the surface height of the object being scanned.

Before the phase is calculated from the readings at each of the scanning lines, the three scanned images are registered so that the phase information from each of the three buckets is from the same point on the scanned surface. The registration correction and the calculation of the phase could be continuous if the electronics can accommodate this mode of operation.

As described above, three scanning lines are utilized. However, there is no reason that more scanning lines cannot be used to increase the number of buckets used in the phase calculation or to average more than one scan line for a bucket. For example, if one had 16 scanning lines, the sum of lines 1 through 4 could be used for bucket 1, the sum of lines 5 through 8 could be used for bucket 2, the sum of lines 9 through 12 could be used for bucket 3, and the sum of lines 13 through 16 could be used for bucket 4.

Case 2 alluded to above would most likely use a CCD area array in the optical head 1 but could use a linear array or

single point photodetector. In this case, as the surface 18 is moved toward or away from the optical head 12, images are taken as the phase of the projection changes. The analysis would consist of correcting for registration between images and then using the images to create the buckets needed for the phase calculation. If the camera images telecetrically or nearly telecetrically, then registration would not be required.

Systems that employ the Case 2 set-up have been described for use in white light interferometry systems as described in U.S. Pat. Nos. 5,398,113 and 5,355,221 but not for a moire (light stripe) application.

Although a method is described above for making phase calculations based on a moire (light stripe) system, the described technique could also be applied to any optical base phenomena where the phase is changed between the images created when moving the object 14 of interest relative to the optical head 12. Techniques that can create this phase change include moire interferometry, white light interferometry, standard monochromatic light optical interferometry, ellipsometry, birefringence, and thermo-wave imaging.

The use of polarization to create an ellipsometer illustrates another optical based phenomena where phase is changed between the images created when moving the object 14 of interest relative to the optical head 12. The adaptation of this scanning phase measuring technique to ellipsometry and birefringence measurement can be understood as an adaptation of a rotating-analyzer ellipsometer (as described at pp. 410–413 of the book entitled "Ellipsometry and Polarized Light," Azzam and Bashara). The rotating-analyzer ellipsometer projects polarized light onto a surface and the polarization of the reflected beam (or transmitted beam depending on geometry) is determined by rotating an analyzer (linear polarizer) in front of the receiving detector. The radiation received at the detector varies as a sinusoidal function that it twice the frequency of the rotating analyzer. The amplitude of the signal is to the degree of linear polarization of the light received at the analyzer and the phase defines the angle of polarization.

Using the scanning phase measuring technique of the present application, the rotating-analyzer would be replaced by three or more analyzers, each of which would have a row of detector elements (scanning lines) behind it to image the received radiation at difference polarized phase values. The object to be measured would be moved past the fixed projector and detector system on an optical head 12" as shown in FIG. 4, wherein polarized light would be projected (instead of a light stripe pattern as described for a height measuring system). Each of the scanning lines measures a different phase of the sinusoidal polarization signal.

Items in FIG. 4 which have the same or similar structure and/or function to the items in the prior figures have a double prime designation. For example:

Reference numeral 12" designates an optical head of a scanning phase measuring ellipsometer;

Reference numeral 14" designates an object whose polarization response will be measured;

Reference number 18" designates a surface of the object 14" whose polarization response will be measured when using a projector 38";

Reference numeral 20" designates relative motion of the measured object 14";

Reference numeral 24" designates a trilinear array camera having analyzers 25";

Reference numeral 36" designates projected polarized light;

Reference numeral 38" designates a polarized light projector for a standard ellipsometer;

Reference numeral 40" designates an imaging lens; and

Reference numeral 42" designates a polarized light projector for an ellipsometer in a transmission mode (birefingence measuring system).

Reference numerals 60, 61 and 62 designate an analyzer system in front of detector lines wherein 60 designates a linear polarizer parallel to the linear array 24", 61 designates a linear polarizer at 45 degrees to the linear array 24", and 62 designates a linear polarizer perpendicular to the linear array 24".

The example shown in FIG. 4 uses a trilinear array camera 24" with the analyzers (linear polarizers) 25" set at 0°, 45°, and 90° for the three scanning lines. In terms of phase shifting technology, each scanning line measures a different "bucket," and a three "bucket" algorithm is used on the computer for measuring the phase and amplitude of the signal received by this scanning analyzer system.

Referring again to the first embodiment of the invention, the optical head 12 includes the light strip projector 28 and the camera includes the imaging lens 40 for focusing the scanned surface onto the trilinear array 24. The scanned surface is translated past the optical head 12 in the direction of the arrow 20. To eliminate perspective effects in both projection and imaging, the project and imaging system should be either telecentric or nearly telecentric. A nearly telecentric system is created by having the standoff from the optics being much larger than the measurement depth range.

For this discussion, the data from the first linear array in the detector is called b1 (for bucket 1). Likewise, the second and third linear arrays is called b2 and b3, respectively. The pitch of the projected light pattern creates a phase difference of ½ a cycle between b1 and b3. For each linear array, let b1(i,j), b2(i,j) and b3(i,j) designate the light intensity measurement for each linear array with j indicating the pixel number and let j indicating the scan number. For example, b2(25,33) would be the intensity reading of the 25 pixel of the second linear array taken from the 33 scan.

The phase value which is proportional to depth is calculated within the computer 28 using the light intensity reading from the trilinear array as the object 14 is moving uniformly past the optical head 12. The preferred equation is:

$$\text{phase value}(i,j)=\arctan[\{b1(i,j)-b2(i,j+m)\}/\{b2(i,j+m)-b3(i,j+2m)\}]$$

where m is an integer that provides the required image shift to match registration between b1, b2 and b3.

In like fashion, the preferred equation for amplitude value is:

$$\text{amplitude value}(i,j)=(((b1(i,j)-b2(i,j+m))^2+(b2(i,j)-b3(i,j+2m))^2)^{**\cdot}$$
fra 1/2+oc

In some instances, it is desirable to project from more than one angle. For example, projecting from each side of the camera can reduce occlusion problems. Projecting with patterns having different contour intervals (the change in depth for one phase cycle) can be used to eliminate ambiguity if the measurement range is more than one contour interval.

Measurements with more than one projector by including a second projector 42 can be accomplished by cycling the part past the optical head and changing which of the projectors 38 or 42 is on for each cycle. Or, one of the illuminating projectors 38 or 42 can be changed for each scan of the array. For example, assuming two projectors, when j is even, the first projector 38 would be on and when

j is odd, the second projector 42 would be on. For calculations to work out properly for this alternating system, then m, the integer shift value, must be even. Thus, using this alternating approach, phase value image for the first projector 38 would be: phase value (i,2j) where j=0,1,2, . . . ; and phase value image for the second projector 42 would be: phase value (i,2j+1) where j=0,1,2, ...

If it is desirable to increase the pitch of the imaged grating pattern, a second grating 44 can be added to the imaging side as illustrated in FIG. 3. In some instances, it is desirable to include an imaging lens between the grating 44 and the array 24. The parts shown in FIG. 3 which have the same or similar function to the parts of FIG. 2 have the same reference numeral but a prime designation.

The beat effect between the two grating patterns is the optical moire effect and will increase the pitch imaged onto the detector. This can be desirable when one wants to use a pitch finer than can be resolved by the detector. That is, the primary pitch is less than the width of a pixel.

While the best mode for carrying out the invention has been described in detail, those familiar with the art to which this invention relates will recognize various alternative designs and embodiments for practicing the invention as defined by the following claims.

What is claimed is:

1. A method for high speed, scanning phase measuring of an object at a vision station to develop physical information associated with the object, the method comprising the steps of:

projecting a pattern of imagable electromagnetic radiation with at least one projector;

moving the object relative to the at least one projector at a substantially constant velocity at the vision station so as to scan the projected pattern of electromagnetic radiation across a surface of the object to generate an imagable electromagnetic radiation signal;

receiving the imagable electromagnetic radiation signal from the surface of the object with a detector having a plurality of separate detector elements which are substantially uniformly spaced;

maintaining the at least one projector and the detector in a substantially fixed relation to each other;

measuring an amount of radiant energy in the received electromagnetic radiation signal with the detector wherein each of the detector elements produce an image having a different phase of the same scanned surface based on the measurement; and

computing phase values and amplitude values for the different phases from the multiple images.

2. The method as claimed in claim 1 wherein the physical information is dimensional information and the imagable electromagnetic radiation is light.

3. The method as claimed in claim 2 wherein the detector has an optical axis and wherein the step of moving is performed in a direction substantially parallel to the optical axis and wherein the projected pattern of light is a stripe of lines.

4. The method as claimed in claim 2 further comprising the step of determining height of the surface of the object based on the phase and amplitude values.

5. The method as claimed in claim 1 wherein the physical information is polarization information, the imagable electromagnetic radiation is polarized, a response of the detector elements is polarization sensitive and wherein the images are based on polarization from the surface.

6. The method as claimed in claim 1 wherein the plurality of detector elements are uniformly spaced and wherein the step of moving is performed uniformly and continuously.

7. The method as claimed in claim 1 wherein the step of computing includes the step of registering the images.

8. The method as claimed in claim 1 wherein the detector elements are elongated in a direction parallel to a detector axis of the detector, and wherein the detector also has an optical axis and wherein the step of moving is performed in a direction substantially perpendicular to the detector and optical axes.

9. The method as claimed in claim 8 wherein the detector is a multi-linear array camera.

10. The method as claimed in claim 8 wherein each detector element is a row of CCD sensing elements extending substantially parallel to the detector axis and wherein the step of moving is performed in a direction substantially perpendicular to the rows of the CCD sensing elements.

11. The method as claimed in claim 1 wherein the step of projecting is performed with two projectors.

12. The method as claimed in claim 11 wherein the step of moving includes the step of cycling the object relative to the two projectors wherein the two projectors alternately project the pattern of imagable electromagnetic radiation.

13. The method as claimed in claim 11 wherein the two projectors alternately project the pattern of imagable electromagnetic radiation during consecutive scans of the projected pattern of imagable electromagnetic radiation.

14. A system for high speed, scanning phase measuring of an object at a vision station to develop physical information associated with the object, the system including:

at least one projector for projecting a pattern of imagable electromagnetic radiation;

means for moving the object relative to the at least one projector at the vision station at a substantially constant velocity so as to scan the projected pattern of imagable electromagnetic radiation across a surface of the object to generate an imagable electromagnetic radiation signal;

a detector for receiving the imagable electromagnetic radiation signal from the surface of the object and having a plurality of separate detector elements which are substantially uniformly spaced for measuring an amount of radiant energy in the imagable electromagnetic radiation signal wherein each of the detector elements produces an image having a different phase of the same scanned surface based on the measurement;

means for maintaining the at least one projector and the detector in a substantially fixed relation to each other; and

means for computing phase values and amplitude values for the different phases from the images.

15. The method as claimed in claim 14 wherein the physical information is dimensional information and the imagable electromagnetic radiation is light.

16. The system as claimed in claim 15 wherein the detector has an optical component for receiving the reflected light signal, the optical component having an optical axis and wherein the means for moving moves the object relative to the at least one projector in a direction substantially parallel to the optical axis and wherein the projected pattern of light is a stripe of lines.

17. The system as claimed in claim 15 further comprising means for determining height of the surface of the object based on the phase and amplitude values.

18. The method as claimed in claim 14 wherein the physical information is polarization information, the imagable electromagnetic radiation is polarized, a response of the detector elements is polarization sensitive and wherein the images are based on polarization from the surface.

19. The system as claimed in claim 14 wherein the plurality of detector elements are uniformly spaced and wherein the means for moving moves the object relative to the at least one projector uniformly and continuously.

20. The system as claimed in claim 14 wherein the means for computing includes means for registering the images.

21. The system as claimed in claim 14 wherein the detector elements are elongated in a direction parallel to a detector axis of the detector and wherein the detector also has an optical component having an optical axis and wherein the means for moving moves the object relative to the at least one projector in a direction substantially perpendicular to the detector and optical axes.

22. The system as claimed in claim 21 wherein the detector is a multi-linear array camera.

23. The system as claimed in claim 21 wherein each detector element is a row of CCD sensing elements extending substantially parallel to the detector axis and wherein the means for moving moves the object relative to the detector

in a direction substantially perpendicular to the rows of the CCD sensing elements.

24. The system as claimed in claim 14 further comprising two projectors, the two projectors projecting the pattern of imagable electromagnetic radiation.

25. The system as claimed in claim 24 wherein the means for moving cycles the object relative to the two projectors wherein the two projectors alternately project the pattern of imagable electromagnetic radiation during consecutive cycles.

26. The system as claimed in claim 24 wherein imagable the two projectors alternately project the pattern of electromagnetic radiation during consecutive scans of the projected pattern of imagable electromagnetic radiation.

27. The system as claimed in claim 14 wherein the at least one projector and the detector at least partially define an optical head.

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Printed Name Charles A. Lemaire

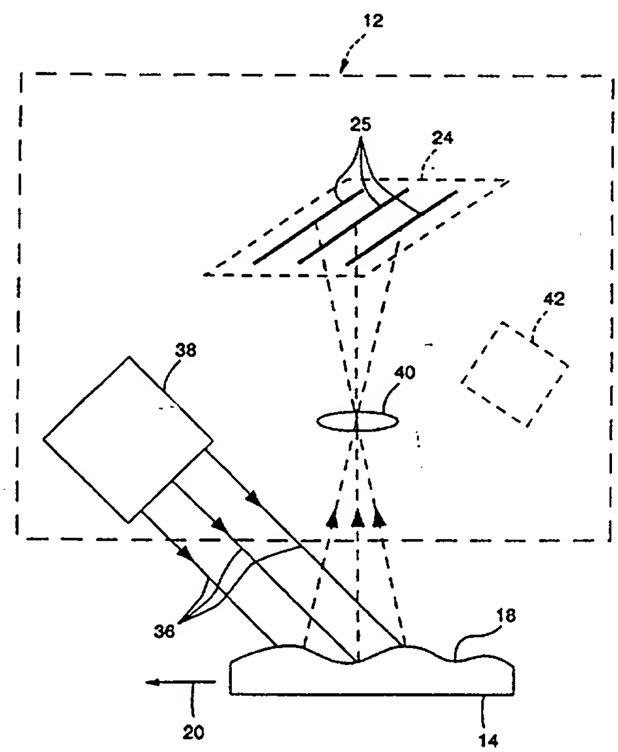
Signature Charles A. Lemaire

Primary Examiner—Hoa Q. Pham
Attorney, Agent, or Firm—Brooks & Kushman P.C.

[57] ABSTRACT

A method and system are provided including an optical head which moves relative to an object at a vision station to scan a projected pattern of imagable electromagnetic radiation across the surface of an object to be inspected at a relatively constant linear rate to generate an imagable electromagnetic radiation signal. In one embodiment, the electromagnetic radiation is light to develop dimensional information associated with the object. The optical head includes at least one projector which projects a grid of lines and an imaging subsystem which includes a trilinear array camera as a detector. The camera and the at least one projector are maintained in fixed relation to each other. Three linear detector elements of the array camera extend in a direction parallel with the grid of lines. The geometry of the optical head is arranged in such a way that each linear detector element picks up a different phase in the grid pattern. As the optical head is scanned across the surface of interest, the detector elements are continuously read out. Depth an each point on the surface is calculated from the intensity reading obtained from each of the detector elements that correspond to the same point on the surface. In this way, the phases of the pattern are calculated from the three intensity readings obtained for each point. In another embodiment, the imagable electromagnetic radiation is polarized and the response of the detector elements is polarization sensitive. The generated images are based on polarization for the surface.

27 Claims, 4 Drawing Sheets



REISSUE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Leonard H. Bieman	Examiner: Unknown
Serial No.:	Unknown	Group Art Unit: Unknown
Filed:	Herewith	Docket: 139.032USR
Title:	SCANNING PHASE MEASURING METHOD AND SYSTEM FOR AN OBJECT AT A VISION STATION	

PRELIMINARY AMENDMENT

BOX PATENT APPLICATION
Assistant Commissioner for Patents
Washington, D.C. 20231

Please amend the above-identified reissue application as follows:

IN THE CLAIMS

Please amend claims 15, 18, and 26 of the patent, and add new claims 28-85 as follows (all claims are reprinted for the Examiner's convenience):

1. A method for high speed, scanning phase measuring of an object at a vision station to develop physical information associated with the object, the method comprising the steps of:

projecting a pattern of imagable electromagnetic radiation with at least one projector;

moving the object relative to the at least one projector at a substantially constant velocity at the vision station so as to scan the projected pattern of electromagnetic radiation across a surface of the object to generate an imagable electromagnetic radiation signal;

receiving the imagable electromagnetic radiation signal from the surface of the object with a detector having a plurality of separate detector elements which are substantially uniformly spaced;

maintaining the at least one projector and the detector in a substantially fixed relation to each other;

measuring an amount of radiant energy in the received electromagnetic radiation signal with the detector wherein each of the detector elements produce an image having a different phase of the same scanned surface based on the measurement; and

computing phase values and amplitude values for the different phases from the multiple images.

2. The method as claimed in claim 1 wherein the physical information is dimensional information and the imagable electromagnetic radiation is light.

3. The method as claimed in claim 2 wherein the detector has an optical axis and wherein the step of moving is performed in a direction substantially parallel to the optical axis and wherein the projected pattern of light is a stripe of lines.

4. The method as claimed in claim 2 further comprising the step of determining height of the surface of the object based on the phase and amplitude values.

5. The method as claimed in claim 1 wherein the physical information is polarization information, the imagable electromagnetic radiation is polarized, a response of the detector elements is polarization sensitive and wherein the images are based on polarization from the surface.

6. The method as claimed in claim 1 wherein the plurality of detector elements are uniformly spaced and wherein the step of moving is performed uniformly and continuously.

7. The method as claimed in claim 1 wherein the step of computing includes the step of registering the images.

8. The method as claimed in claim 1 wherein the detector elements are elongated in a direction parallel to a detector axis of the detector, and wherein the detector also has an optical axis and wherein the step of moving is performed in a direction substantially perpendicular to the detector and optical axes.

9. The method as claimed in claim 8 wherein the detector is a multi-linear array camera.

10. The method as claimed in claim 8 wherein each detector element is a row of CCD sensing elements extending substantially parallel to the detector axis and wherein the step of moving is performed in a direction substantially perpendicular to the rows of the CCD sensing elements.

11. The method as claimed in claim 1 wherein the step of projecting is performed with two projectors.

12. The method as claimed in claim 11 wherein the step of moving includes the step of cycling the object relative to the two projectors wherein the two projectors alternately project the pattern of imagable electromagnetic radiation.

13. The method as claimed in claim 11 wherein the two projectors alternately project the pattern of imagable electromagnetic radiation during consecutive scans of the projected pattern of imagable electromagnetic radiation.

14. A system for high speed, scanning phase measuring of an object at a vision station to develop physical information associated with the object, the system including:

at least one projector for projecting a pattern of imagable electromagnetic radiation;

means for moving the object relative to the at least one projector at the vision station at a substantially constant velocity so as to scan the projected pattern of imagable electromagnetic radiation across a surface of the object to generate an imagable electromagnetic radiation signal;

a detector for receiving the imagable electromagnetic radiation signal from the surface of the object and having a plurality of separate detector elements which are substantially uniformly spaced for measuring an amount of radiant energy in the imagable electromagnetic radiation signal wherein each of the detector elements produces an image having a different phase of the same scanned surface based on the measurement;

means for maintaining the at least one projector and the detector in a substantially fixed

relation to each other; and

means for computing phase values and amplitude values for the different phases from the images.

15. [Amended] The [method] system as claimed in claim 14 wherein the physical information is dimensional information and the imagable electromagnetic radiation is light.

16. The system as claimed in claim 15 wherein the detector has an optical component for receiving the reflected light signal, the optical component having an optical axis and wherein the means for moving moves the object relative to the at least one projector in a direction substantially parallel to the optical axis and wherein the projected pattern of light is a stripe of lines.

17. The system as claimed in claim 15 further comprising means for determining height of the surface of the object based on the phase and amplitude values.

18. [Amended] The [method] system as claimed in claim 14 wherein the physical information is polarization information, the imagable electromagnetic radiation is polarized, a response of the detector elements is polarization sensitive and wherein the images are based on polarization from the surface.

19. The system as claimed in claim 14 wherein the plurality of detector elements are uniformly spaced and wherein the means for moving moves the object relative to the at least one projector uniformly and continuously.

20. The system as claimed in claim 14 wherein the means for computing includes means for registering the images.

21. The system as claimed in claim 14 wherein the detector elements are elongated in a direction parallel to a detector axis of the detector and wherein the detector also has an optical component having an optical axis and wherein the means for moving moves the object relative to the at least one projector in a direction substantially perpendicular to the detector and optical axes.

22. The system as claimed in claim 21 wherein the detector is a multi-linear array camera.

23. The system as claimed in claim 21 wherein each detector element is a row of CCD sensing elements extending substantially parallel to the detector axis and wherein the means for moving moves the object relative to the detector in a direction substantially perpendicular to the rows of the CCD sensing elements.

24. The system as claimed in claim 14 further comprising two projectors, the two projectors projecting the pattern of imagable electromagnetic radiation.

25. The system as claimed in claim 24 wherein the means for moving cycles the object relative to the two projectors wherein the two projectors alternately project the pattern of imagable electromagnetic radiation during consecutive cycles.

26. [Amended] The system as claimed in claim 24 wherein [imagable] the two projectors alternately project the pattern of electromagnetic radiation during consecutive scans of the projected pattern of imagable electromagnetic radiation.

27. The system as claimed in claim 14 wherein the at least one projector and the detector at least partially define an optical head.

28. [New] The method as claimed in claim 2 wherein the detector has an optical axis and wherein the step of moving is performed in a direction substantially perpendicular to the optical axis and wherein the projected pattern of light is a stripe of lines.

29. [New] The system as claimed in claim 15 wherein the detector has an optical component for receiving the reflected light signal, the optical component having an optical axis and wherein the means for moving moves the object relative to the at least one projector in a direction substantially perpendicular to the optical axis and wherein the projected pattern of light is a stripe of lines.

30. [New.] A method for high-speed scanning measurement of an object at a vision station, the vision station having a detector, in order to determine dimensional information associated with the object, the method comprising the steps of:

projecting a pattern of light;

maintaining the projected pattern of light and the detector in a substantially fixed relation to each other;

moving the object relative to the projected pattern of light so as to scan the projected pattern of light across a surface of the object to generate an imagable light signal;

imaging the imagable light signal onto the detector, the detector having a first, a second, and a third detector element, wherein the surface of the object is imaged onto the first detector element at a first phase of the projected pattern of light, the surface of the object is imaged onto the second detector element at a second phase of the projected pattern of light, and the surface of the object is imaged onto the third detector element at a third phase of the projected pattern of light;

measuring with the detector an amount of light from the surface of the object to the first detector element at the first phase, to the second detector element at the second phase, and to the third detector element at the third phase; and

computing dimensional information based on the measuring step.

31. [New.] The method according to claim 30, wherein each one of the first, second, and third detector element includes a plurality of detector pixel elements.

32. [New.] The method according to claim 30, wherein the detector has an optical axis and wherein the step of moving is performed in a direction substantially perpendicular to the optical axis and wherein the projected pattern of light includes a stripe of lines.

33. [New.] The method according to claim 30, further comprising the step of determining a height of the surface of the object based on phase and amplitude values from the measuring step.

34. [New.] The method according to claim 30, wherein a spacing between the first and second detector element is substantially equal to a corresponding spacing between the second and the third detector element, and wherein the step of moving is performed at a substantially uniform velocity.

35. [New.] The method according to claim 30, wherein the step of computing includes the step of registering the images.

36. [New.] The method according to claim 30, wherein the detector elements are elongated in a direction parallel to a detector axis of the detector, and wherein the detector also has an optical axis and wherein the step of moving is performed in a direction substantially perpendicular to the detector axis and substantially perpendicular to the optical axis.

37. [New.] The method according to claim 36, wherein the detector includes a tri-linear array camera.

38. [New.] The method according to claim 30, wherein each detector element includes a row of CCD sensing elements extending substantially parallel to the detector axis and wherein the step of moving is performed in a direction substantially perpendicular to the rows of the CCD sensing elements.

39. [New.] The method according to claim 30, wherein the step of projecting includes the step of projecting with two projected patterns of light.

40. [New.] The method according to claim 39, wherein the step of moving includes the step of cycling the object relative to the two projected patterns of light, and wherein the two projected patterns of light are alternately projected.

41. [New.] The method according to claim 39, wherein the two projected patterns of light are alternately projected during consecutive scans.

42. [New.] A system for high-speed scanning measurement of an object at a vision station in order to determine dimensional information associated with the object, the system including:

a first projector that projects a pattern of light, the pattern of light having a first, a second, and a third phase;

a drive that moves the object relative to the first projector at the vision station so as to scan the projected pattern of light across a surface of the object to generate an object light signal;

a detector having a first, a second, and a third detector element that each generate an image value representing an amount of light in the object light signal from the scanned surface of the object, wherein the first detector element produces a first image value based on an image of the scanned surface at the first phase of the projected pattern of light, the second detector element produces a second image value based on an image of the scanned surface at the second phase, and the third detector element produces a third image value based on an image of the scanned surface at the third phase, and wherein the detector is maintained in a substantially fixed relation to the first projector; and

a computational element coupled to the detector that computes the dimensional information associated with the object based on the first, second, and third image values.

43. [New.] The system according to claim 42, wherein each detector element includes a plurality of detector pixels elements.

44. [New.] The system according to claim 42, wherein the detector has an optical element for receiving the object light signal, the optical element having an optical axis, and wherein the drive moves the object relative to the first projector in a direction substantially perpendicular to the optical axis and wherein the projected pattern of light includes a stripe of lines.

45. [New.] The system according to claim 42, wherein the computational element computes a height of the surface of the object based on the first, second, and third image values.

46. [New.] The system according to claim 42, wherein the pattern of light is polarized and a response of the detector elements is polarization sensitive.

47. [New.] The system according to claim 42, wherein a spacing between the first and second detector element is substantially equal to a corresponding spacing between the second and the third detector element, and wherein the step of moving is performed at a substantially uniform velocity.

48. [New.] The system according to claim 42, wherein the computational element registers the images.

49. [New.] The system according to claim 42, wherein:

the detector elements are elongated in a direction parallel to a detector axis of the detector;

the detector also has an optical element having an optical axis; and

the drive moves the object relative to the first projector in a direction substantially perpendicular to the detector axis and substantially perpendicular to the optical axis.

50. [New.] The system according to claim 49, wherein the detector includes a tri-linear array camera.

51. [New.] The system according to claim 42, wherein:

each detector element includes a row of CCD sensing elements extending substantially parallel to the detector axis, and

the drive moves the object relative to the detector in a direction substantially perpendicular to the rows of the CCD sensing elements.

52. [New.] The system according to claim 42, further comprising a second projector, the first and second projectors projecting the pattern of light.

53. [New.] The system according to claim 52, wherein the drive cycles the object relative to the two projectors wherein the two projectors alternately project the pattern of light during consecutive cycles.

54. [New.] The system according to claim 52, wherein the two projectors alternately project the pattern of light during consecutive scans of the projected pattern of light.

55. [New.] The system according to claim 42, wherein the projector and the detector define at least part of an optical head.

56. [New.] A system for high-speed scanning height measurement of an object at a vision station in order to determine dimensional information associated with the object, the system comprising:

an optical head, the optical head including:

a projector that projects a pattern of light, the projected pattern of light varying in intensity as a function of position and having a first, a second, and a third intensity; and

a detector having a first, a second, and a third detector element that each generate an image value representing an amount of light in the imagable light signal from the scanned surface of the object, wherein the first detector element produces a first image value based on an image of the scanned surface at the first intensity of the projected pattern of light, the second detector element produces a second image value based on an image of the scanned surface at the second intensity, and the third detector element produces a third image value based on an image of the scanned surface at the third intensity, and wherein the detector is maintained in a substantially fixed relation to the projected pattern of light.

57. [New.] The system according to claim 56, further comprising

a drive that moves the object relative to the projector at the vision station so as to scan the projected pattern of light across a surface of the object to generate an imagable light signal;

58. [New.] The system according to claim 56, further comprising

a computational element coupled to the detector that computes the dimensional information associated with the object based on the first, second, and third image values.

59. [New.] The system according to claim 56, wherein the detector includes a tri-linear array.

60. [New.] A method for high-speed scanning measurement of an object at a vision station, the vision station having a detector, in order to determine dimensional information associated with the object, the method comprising the steps of:

projecting a pattern of light, the projected pattern of light having a first, a second, and a third intensity at first, a second, and a third position, respectively;

maintaining the projected pattern of light and the detector in a substantially fixed relation

to each other;

moving the object relative to the projected pattern of light so as to scan the projected pattern of light across a surface of the object to generate an imagable light signal;

imaging the imagable light signal onto the detector, the detector having a first, a second, and a third detector element, wherein the surface of the object is imaged onto the first detector element at the first intensity of the projected pattern of light, the surface of the object is imaged onto the second detector element at the second intensity of the projected pattern of light, and the surface of the object is imaged onto the third detector element at the third intensity of the projected pattern of light;

measuring with the detector an amount of light from the surface of the object to the first detector element at the first intensity, to the second detector element at the second intensity, and to the third detector element at the third intensity; and

computing dimensional information based on the measuring step.

61. [New.] The method according to claim 60, wherein each one of the first, second, and third detector element includes a plurality of detector pixel elements.

62. [New.] The method according to claim 60, wherein the detector has an optical axis and wherein the step of moving is performed in a direction substantially perpendicular to the optical axis and wherein the projected pattern of light includes a stripe of lines.

63. [New.] The method according to claim 60, further comprising the step of determining a height of the surface of the object based on phase and amplitude values from the measuring step.

64. [New.] The method according to claim 60, wherein a spacing between the first and second detector element is substantially equal to a corresponding spacing between the second and the third detector element, and wherein the step of moving is performed at a substantially uniform velocity.

65. [New.] The method according to claim 60, wherein the step of computing includes the step of registering the images.

66. [New.] The method according to claim 60, wherein the detector elements are elongated in a direction parallel to a detector axis of the detector, and wherein the detector also has an optical axis and wherein the step of moving is performed in a direction substantially perpendicular to the detector axis and substantially perpendicular to the optical axis.

67. [New.] The method according to claim 66, wherein the detector includes a tri-linear array camera.

68. [New.] The method according to claim 60, wherein each detector element includes a row of CCD sensing elements extending substantially parallel to the detector axis and wherein the step of moving is performed in a direction substantially perpendicular to the rows of the CCD sensing elements.

69. [New.] The method according to claim 60, wherein the step of projecting includes the step of projecting with two projected patterns of light.

70. [New.] The method according to claim 69, wherein the step of moving includes the step of cycling the object relative to the two projected patterns of light, and wherein the two projected patterns of light are alternately projected.

71. [New.] The method according to claim 69, wherein the two projected patterns of light are alternately projected during consecutive scans.

72. [New.] A system for high-speed scanning measurement of an object at a vision station in order to determine dimensional information associated with the object, the system including:

a first projector that projects a pattern of light, the pattern of light having a first, a second,

and a third intensity;

a drive that moves the object relative to the first projector at the vision station so as to scan the projected pattern of light across a surface of the object to generate an object light signal;

a detector having a first, a second, and a third detector element that each generate an image value representing an amount of light in the object light signal from the scanned surface of the object, wherein the first detector element produces a first image value based on an image of the scanned surface at the first intensity of the projected pattern of light, the second detector element produces a second image value based on an image of the scanned surface at the second intensity, and the third detector element produces a third image value based on an image of the scanned surface at the third intensity, and wherein the detector is maintained in a substantially fixed relation to the first projector; and

a computational element coupled to the detector that computes the dimensional information associated with the object based on the first, second, and third image values.

73. [New.] The system according to claim 72, wherein each detector element includes a plurality of detector pixel elements.

74. [New.] The system according to claim 72, wherein the detector has an optical element for receiving the object light signal, the optical element having an optical axis, and wherein the drive moves the object relative to the first projector in a direction substantially perpendicular to the optical axis and wherein the projected pattern of light includes a stripe of lines.

75. [New.] The system according to claim 72, wherein the computational element computes a height of the surface of the object based on the first, second, and third image values.

76. [New.] The system according to claim 72, wherein the pattern of light is polarized and a response of the detector elements is polarization sensitive.

77. [New.] The system according to claim 72, wherein a spacing between the first and second detector element is substantially equal to a corresponding spacing between the second and the third detector element, and wherein the step of moving is performed at a substantially uniform velocity.

78. [New.] The system according to claim 72, wherein the computational element registers the images.

79. [New.] The system according to claim 72, wherein:

the detector elements are elongated in a direction parallel to a detector axis of the detector;

the detector also has an optical element having an optical axis; and

the drive moves the object relative to the first projector in a direction substantially perpendicular to the detector axis and substantially perpendicular to the optical axis.

80. [New.] The system according to claim 79, wherein the detector includes a tri-linear array camera.

81. [New.] The system according to claim 77, wherein:

each detector element includes a row of CCD sensing elements extending substantially parallel to the detector axis, and

the drive moves the object relative to the detector in a direction substantially perpendicular to the rows of the CCD sensing elements.

82. [New.] The system according to claim 72, further comprising a second projector, a second projector, the first and second projectors projecting the pattern of light.

83. [New.] The system according to claim 82, wherein the drive cycles the object relative to the two projectors wherein the two projectors alternately project the pattern of light during consecutive cycles.

84. [New.] The system according to claim 82, wherein the two projectors alternately project the pattern of light during consecutive scans of the projected pattern of light.

85. [New.] The system according to claim 72, wherein the projector and the detector define at least part of an optical head.

REMARKS

Claims 15, 18, and 26 of the patent have been amended to correct typographical errors. New claims 28-85 have been added to more fully describe the invention described in the patent. Eighty-five claims remain for consideration.

Five new independent claims, 30, 42, 56, 60, and 72, have been added. Claims 30, 42, 60, and 72 remove the limitation to moving "at a substantially constant velocity" as was found in issued claims 1 and 14. Claim 56 addresses the invention of the optical head, without reciting other portions of the system apparatus. These new claims are supported by claims 1 and 14 of the original application, by Figure 2, by column 4 lines 10-18, and by the abstract lines 1-8, and numerous other places in the specification. Applicant respectfully submits that, due to error which arose without any deceptive intent on the part of Applicant, the original patent is partially inoperative by reason of claiming more of less than the patentee had a right to claim. In particular, the claims of the patent unnecessarily include limitations in the independent claims to moving "at a substantially constant velocity" and having a detector having a plurality of separate detector elements "which are substantially uniformly spaced," which limitations are not required to distinguish over the cited prior art.

By removing these limitations, the new claims are broader than the issued claims in one or more respects. However, the present reissue application is being filed within two years from the grant of the original patent, pursuant to 35 U.S.C. §251. Further, other limitations, not present in the original claims of the application, were added to these new claims, and thus the recapture rule has not been violated. *Ball Corp. v. U.S.*, 221 USPQ 289, 295 (Fed. Cir. 1984). The new claims distinguish over the references cited in the original patent, and thus appear in condition for allowance, and such action is respectfully requested.

SUPPORT FOR THE NEW CLAIMS

New method claims 30 and 60 address using a light pattern, and are supported by claims 1 and 2 and the abstract lines 1-8 of the patent. New apparatus claims 42 and 72 address using a light pattern, and are supported by claims 14 and 15 and the abstract lines 1-8 of the patent.

New claims 28-29, 32, 44, 62, and 74 recite moving in a direction perpendicular to the optical axis, and wherein the projected pattern of light is a stripe of lines, and are supported on column 4 lines 23-25 of the patent, and claims 3 and 16 of the patent.

New claims 31, 43, 61, and 73 recite detector elements having a plurality of pixel elements, and are supported on column 3 lines 56-58 of the patent.

New claims 33, 45, 63, and 75 recite computing a height of the surface of the object, and are supported on column 6 lines 40-54 of the patent, and claims 4 and 17 of the patent.

New claims 34, 47, 64, and 77 recite a spacing between the first and second detector element is substantially equal to a corresponding spacing between the second and the third detector element, and wherein the step of moving is performed at a substantially uniform velocity, and are supported on column 3 lines 56-58 of the patent, and claims 1, 6, 14, and 19 of the patent.

New claims 35, 48, 65, and 78 recite registering the images, and are supported on column 4 lines 50-52 of the patent.

New claims 36, 49, 66, and 79 recite detector elements are elongated in a direction parallel to a detector axis of the detector; the detector also has an optical element having an optical axis; and the drive moves the object relative to the first projector in a direction substantially perpendicular to the detector axis and substantially perpendicular to the optical axis, and are supported on column 4 lines 28-31 of the patent.

New claims 37, 50, 59, 67, and 80 recite the detector includes a tri-linear array camera, and are supported on column 3 lines 54-55 of the patent.

New claims 38, 51, 68, and 81 recite each detector element includes a row of CCD sensing elements extending substantially parallel to the detector axis and wherein the step of moving is performed in a direction substantially perpendicular to the rows of the CCD sensing elements, and are supported on column 3 lines 54-55 of the patent, and column 4 lines 28-31 of the patent.

New claims 39 and 69 recite projecting with two projected patterns of light, and are supported on column 6 lines 54-67 of the patent.

New claims 40 and 70 recite cycling the object relative to the two projected patterns of

light, and wherein the two projected patterns of light are alternately projected, and are supported on column 6 line 66 to column 7 line 1 of the patent.

New claims 41 and 71 recite the two projected patterns of light are alternately projected during consecutive scans, and are supported on column 6 line 64-66 of the patent.

New claims 52 and 82 recite a second projector, the first and second projectors projecting the pattern of light, and are supported on column 6 line 61-66 of the patent.

New claims 53 and 83 recite the drive cycles the object relative to the two projectors wherein the two projectors alternately project the pattern of light during consecutive cycles, and are supported on column 6 line 66 to column 7 line 1 of the patent.

New claims 54 and 84 recite the two projectors alternately project the pattern of light during consecutive scans of the projected pattern of light, and are supported on column 6 line 64-66 of the patent.

New claims 55 and 85 recite the projector and the detector define at least part of an optical head, and are supported on column 6 line 64-66 of the patent.

New claim 57 recites a drive that moves the object relative to the projector at the vision station so as to scan the projected pattern of light across a surface of the object to generate an imagable light signal, and is supported on column 3 lines 48-50 of the patent.

New claim 58 recites a computational element coupled to the detector that computes the dimensional information associated with the object based on the first, second, and third image values, and is supported on column 3 lines 43-44 and column 6 lines 40-48 of the patent.

A total of 7 independent claims and a total of 85 claims remain for consideration. A check for the fees of the reissue examination for 6 independent and 85 total claims is attached. The Examiner is authorized to charge any additional fees due or credit any overpayment to deposit account 19-0743.

CONCLUSION

Applicant believes that all claims are in condition for allowance. Consideration of the amended and new claims for reissue and allowance of all eighty-five claims is respectfully requested. The Examiner is invited to contact the Applicant's attorney if prosecution of the present reissue application can be assisted thereby.

Respectfully submitted,
Leonard H. Bieman

By his Representatives,

SCHWEGMAN, LUNDBERG, WOESSNER & KLUTH, P.A.
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(612) 373-6949

Date 8 July 1998 By Charles A. Lemaire

Charles A. Lemaire
Reg. No. 36,198

"Express Mail" mailing label no. EM 287 849 544 US
Date of Deposit: 8 July 1998
I hereby certify that this paper or fee is being deposited with the United States Postal Service as "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and in an envelope addressed to Assistant Commissioner for Patents, Washington, D.C. 20231.

Charles A. Lemaire (Name) Charles A. Lemaire (Signature) 8 July 1998 (date)

REISSUE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Leonard H. Bieman	Examiner: Unknown
Serial No.:	Unknown	Group Art Unit: Unknown
Filed:	Herewith	Docket: 139.032USR
Title:	SCANNING PHASE MEASURING METHOD AND SYSTEM FOR AN OBJECT AT A VISION STATION	

REQUEST FOR TITLE REPORT

BOX PATENT APPLICATION
Assistant Commissioner for Patents
Washington, D.C. 20231

Please provide a title report on U.S. Patent No. 5,646,733, issued on July 8, 1997, to Leonard H. Bieman, and entitled "SCANNING PHASE MEASURING METHOD AND SYSTEM FOR AN OBJECT AT A VISION STATION." The title report is for the reissue application filed herewith. Applicant requests that the title report be placed in the above-identified reissue application pursuant to 37 C.F.R. §1.171.

A check to pay the $25.00 fee is required for the title report under 37 C.F.R.§1.19(b)(4) is enclosed herewith. Please charge any addition fees or credit any overpayment to Deposit Account No. 19-0743.

Respectfully submitted,

Leonard H. Bieman
By his Representatives,
SCHWEGMAN, LUNDBERG, WOESSNER & KLUTH, P.A.
P.O. Box 2938
Minneapolis, MN 55402
(612) 373-6949

Date 8 July 1998 By Charles A Lemaire

Charles A. Lemaire
Reg. No. 36,198

"Express Mail" mailing label number: EM287849544US

Date of Deposit: July 8, 1998

I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231

Printed Name Charles A. Lemaire

Signature Charles A Lemaire

REISSUE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Leonard H. Bieman	Examiner: Unknown
Serial No.:	Unknown	Group Art Unit: Unknown
Filed:	Herewith	Docket: 139.032USR
Title:	SCANNING PHASE MEASURING METHOD AND SYSTEM FOR AN OBJECT AT A VISION STATION	

REQUEST TO TRANSFER DRAWINGS

BOX PATENT APPLICATION
Assistant Commissioner for Patents
Washington, D.C. 20231

Please transfer the drawings for U.S. Patent No. 5,646,733, issued on July 8, 1997, to Leonard H. Bieman, and entitled "SCANNING PHASE MEASURING METHOD AND SYSTEM FOR AN OBJECT AT A VISION STATION," to the reissue application filed herewith. A copy of the printed drawings of the patent is attached hereto.

No fee is belived to be due to request the transfer of the drawings. However, if a fee is due, please charge the fee to Deposit Account No. 19-0743.

Respectfully submitted,

By their Representatives,

SCHWEGMAN, LUNDBERG, WOESSNER & KLUTH, P.A.
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Date 8 July 1998 By Charles A Lemaire

Charles A. Lemaire
Reg. No. 36,198

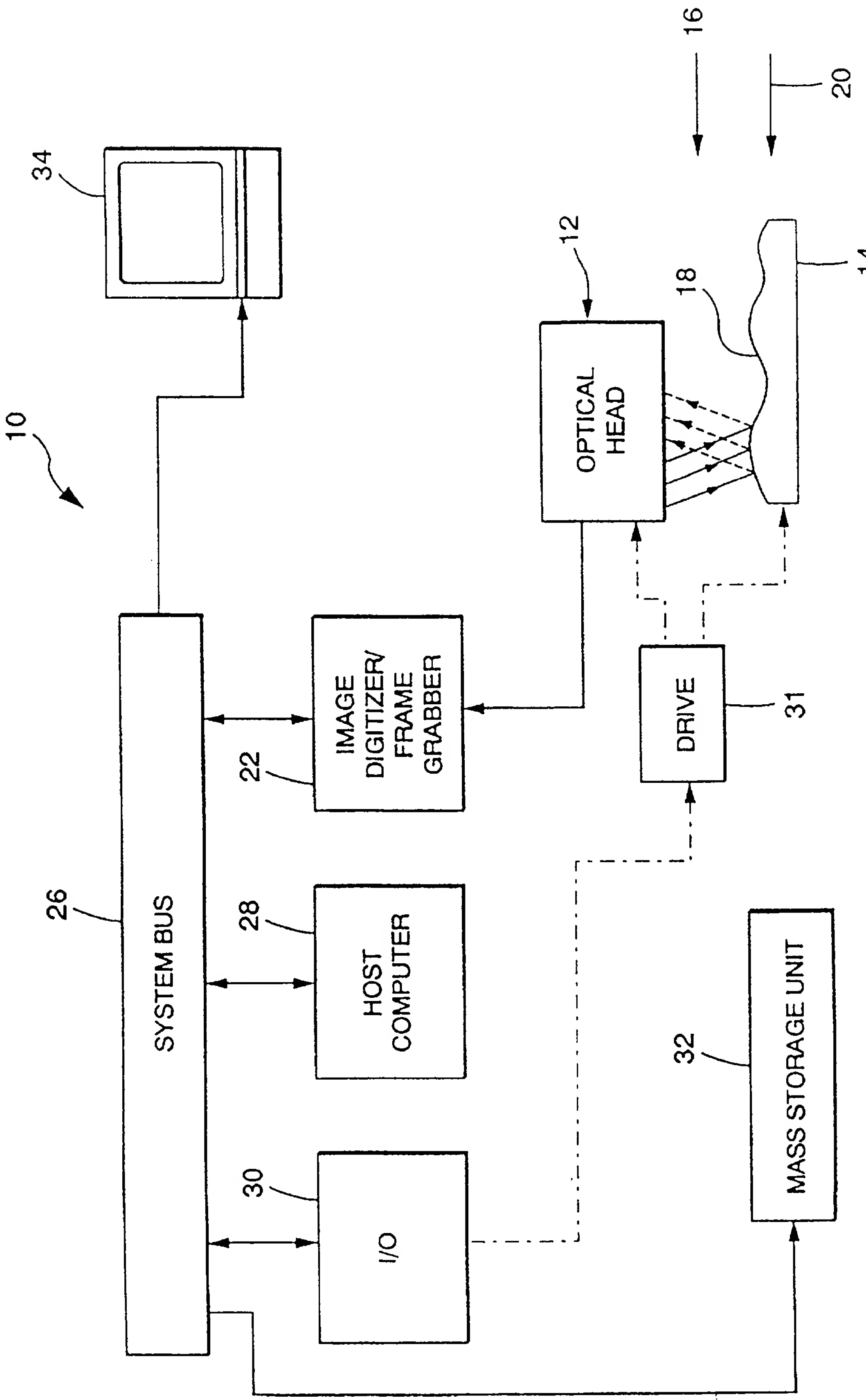
"Express Mail" mailing label number: EM287849544US

Date of Deposit: July 8, 1998

I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231

Printed Name Charles A Lemaire

Signature Charles A Lemaire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SYSTEM BUS
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IMAGE DIGITIZER/ FRAME GRABBER
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I/O
30
DRIVE
31
MASS STORAGE UNIT
32

Fig. 1

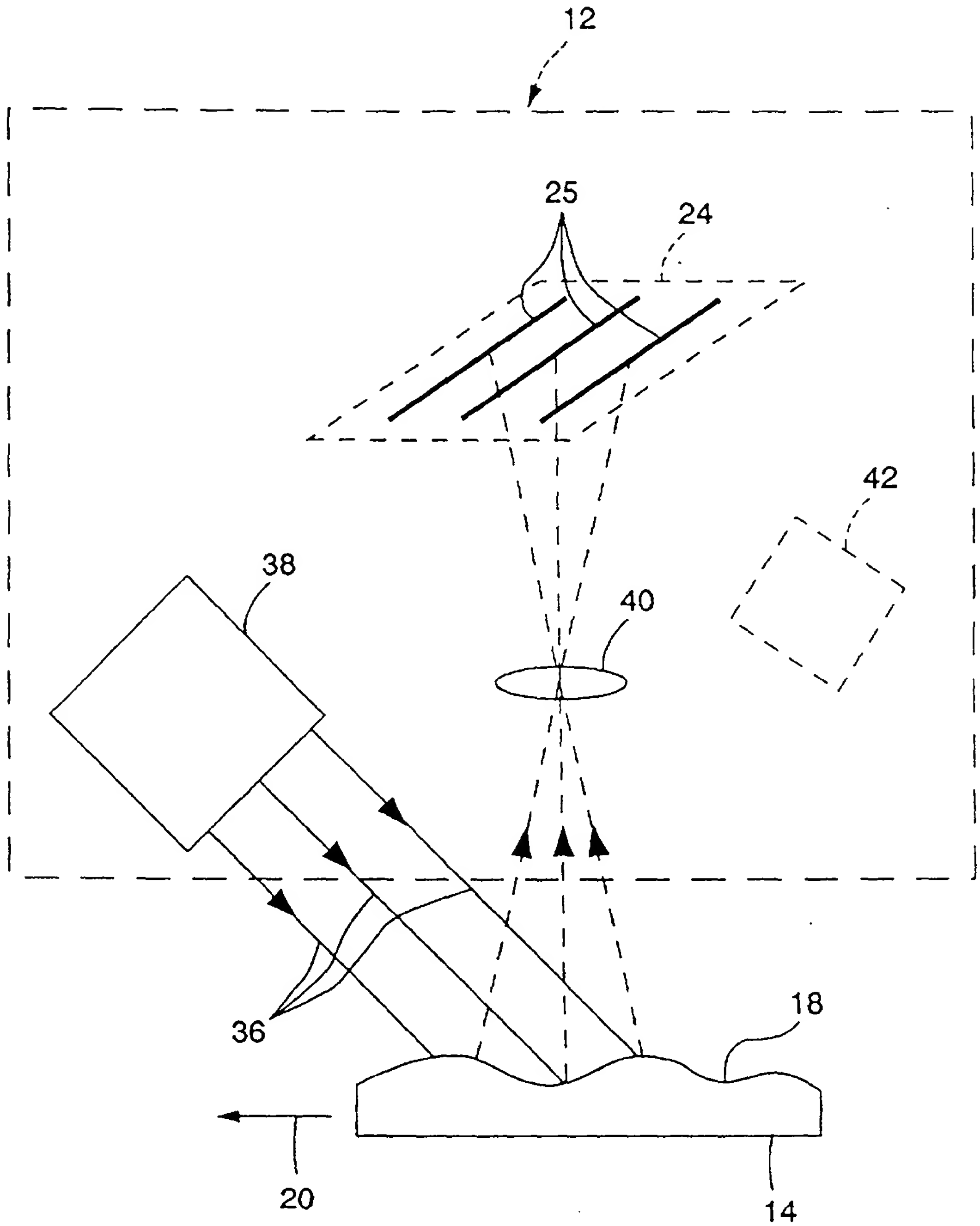

Fig. 2

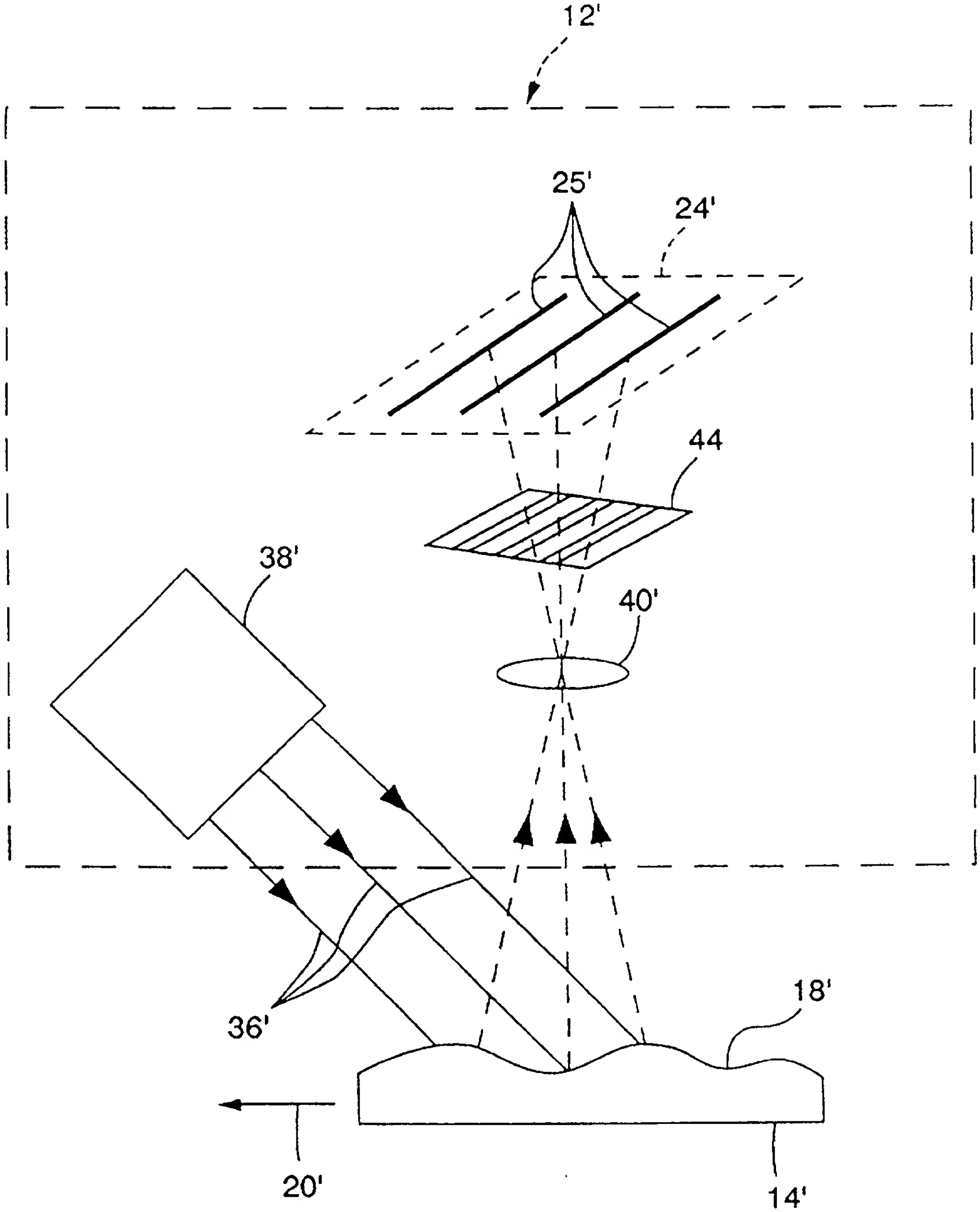

Fig. 3

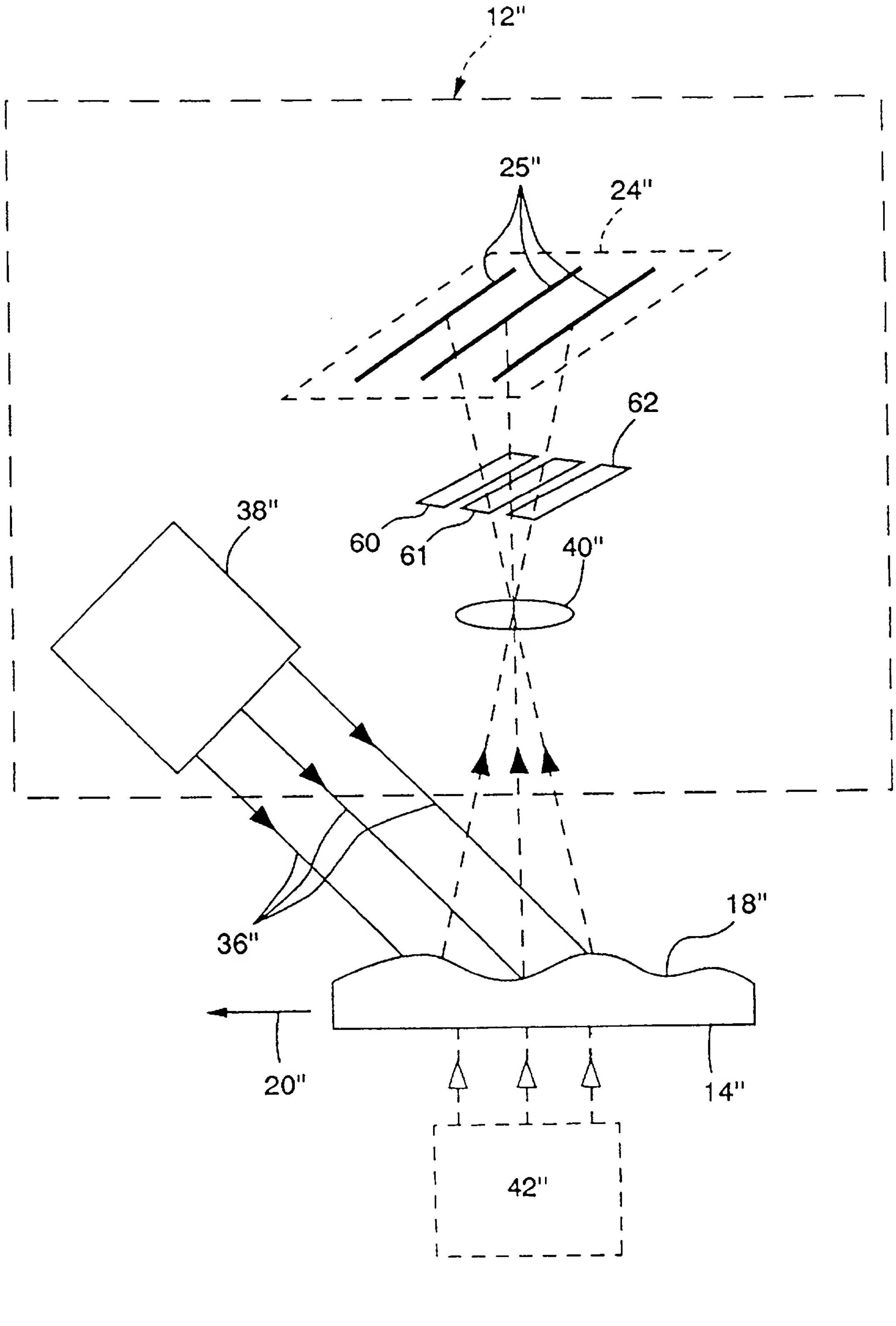

Fig. 4

REISSUE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Leonard H. Bieman

Serial No.: Unknown

Filed: Concurrently Herewith Docket: 139.044US1

Title: SCANNING PHASE MEASURING METHOD AND SYSTEM FOR AN OBJECT AT A VISION STATION

DECLARATION OF INVENTOR

BOX PATENT APPLICATION
Assistant Commissioner for Patents
Washington, D.C. 20231

I, Leonard H. Bieman, hereby declare as follows:

1. I am a citizen of the United States residing at______________________ USA.

2. I believe that I am the original inventor of the invention disclosed and claimed in U.S. Patent No. 5,646,733, issued on July 8, 1997, entitled "SCANNING PHASE MEASURING METHOD AND SYSTEM FOR AN OBJECT AT A VISION STATION," and described and claimed in the accompanying application for which I solicit a reissue patent.

3. I have reviewed and understand the contents of the specification and claims of the reissue application.

4. I do not believe that the invention set forth herein was ever known or used in the United States before the invention thereof by me.

5. I acknowledge the duty to disclose information which is material to the examination to the reissue application in accordance with 37 C.F.R. § 1.56(a).

6. After reading the opinion of outside patent counsel, I believe the above-identified patent

is partially inoperative by reason of claiming less than I, the inventor, had a right to claim in the patent. Such inoperativeness includes particularly the failure to prosecute and obtain claims commensurate with the scope of new claims 28-85 filed in the reissue application.

7. More particularly, I declare that I believe the claims of the patent were determined to be insufficient to protect the invention disclosed in the specification during a review of the scope of the 5,646,733 patent by Charles A. Lemaire, outside patent counsel for PPT Vision, Inc. being the assignee of the present invention, beginning in approximately September 1997 a part of an investigation of the patent prior to a license and later purchase of the patent from the original assignee, Medar, Inc., and culminating in the reissue application.

8. U.S. application Serial No. 08/593,095 was filed on January 29, 1996 with twenty-seven claims. The claims were rejected under 35 U.S.C. § 103 over Kuchel (5,135,308) in view of Bullock et al. (5,488,478) in a first Office Action mailed 8/13/96.

10. The claims 1 and 14 of U.S. application Serial No. 08/593,095 were amended in an Amendment and Response filed November 12, 1996. The amendment was entered accordingly and the claims as amended issued (some renumbered) as claims 1-27 in U.S. Patent No. 5,646,733.

11. After reading the opinion of outside patent counsel, I now believe that other patentably distinct independent claims are possible for claiming aspects of the invention. The existing independent claims 1 and 14 contain limitations or features which, if eliminated, result in patentably distinct claims. In particular, the requirement of moving at a substantially constant velocity and having substantially uniformly spaced detector elements are unnecessarily limiting and can be deleted without adding new matter.

12. New claim 40 is an independent claim and has eliminated the above-noted limitations

present in claim 1, but contains other limitations that make it narrower than the original claim 1. New claim 42 is an independent claim and has eliminated the above-noted limitation present in claim 14, but contains other limitations that make it narrower than the original claim 1. Thus these claims avoid the prohibition against recapture of the same or broader scope of cancelled claims (*Ball Corp. v. United States,* 221 USPQ 289,295 (CAFC 1984)).

13. On information and belief, I further declare that the reasons which render U.S. Patent No. 5,646,733 partially inoperative arose without any fraudulent or deceptive intention on my part, and, as the reissue applicant, upon being informed of the significance of the foregoing facts, I concur in the filing of the reissue application by the assignee.

14. I further declare that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true, and further, that these statements are made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the reissue application or any patent issuing thereon.

Dated: ______________________ ______________________________

Leonard H. Bieman

STATE OF ________)
)ss.
COUNTY OF ________)

On this ___ day of __________, 1997 before me personally appeared Leonard H. Bieman to me known and known to me to be the person described in and who executed the foregoing instrument, and he/she duly acknowledged to me that he/she executed the same for the uses and purposes therein set forth.

[SEAL] ______________________________

Notary Public

SMALL BUSINESS

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS
(37 C.F.R. 1.9(f) AND 1.27(c)) - SMALL BUSINESS CONCERN

I hereby declare that I am
a) () the owner of the small business concern identified below:

b) () an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF CONCERN: PPT Vision, Inc.
ADDRESS OF CONCERN: 10321 West 70th Street
Eden Prairie, MN 55344

I hereby declare that the above identified small business concern qualifies as a small business concern as defined in 13 C.F.R. 121.3-18, and reproduced in 37 C.F.R. 1.9(d), for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention, entitled SCANNING PHASE MEASURING METHOD AND SYSTEM FOR AN OBJECT AT A VISION STATION by inventor described in the specification filed herewith.

If the rights held by the above-identified small business concern are not exclusive, each individual, concern or organization having rights to the invention is listed below* and no rights to the invention are held by any person, other than the inventor, who could not qualify as an independent inventor under 37 C.F.R. 1.9(c) or by any concern which would not qualify as a small business concern under 37 C.F.R. 1.9(d) or a nonprofit organization under 37 C.F.R. 1.9(e). *NOTE: Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 C.F.R. 1.27)

NAME ______
ADDRESS ______
a) () INDIVIDUAL b) () SMALL BUSINESS CONCERN c) ()NONPROFIT ORGANIZATION

NAME ______
ADDRESS ______
a) () INDIVIDUAL b) () SMALL BUSINESS CONCERN c) ()NONPROFIT ORGANIZATION

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 C.F.R. 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereof, or any patent to which this verified statement is directed.

NAME Joseph C. Christenson
TITLE President
ADDRESS 10321 West 70th Street, Eden Prairie, MN 55344-3446
SIGNATURE Joseph C. Christenson DATE 7/8/98

REISSUE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Leonard H. Bieman	Examiner: Unknown
Serial No.:	Unknown	Group Art Unit: Unknown
Filed:	Herewith	Docket: 139.032USR
Title:	SCANNING PHASE MEASURING METHOD AND SYSTEM FOR AN OBJECT AT A VISION STATION	

OFFER TO SURRENDER ORIGINAL PATENT

BOX PATENT APPLICATION
Assistant Commissioner for Patents
Washington, D.C. 20231

In accord with the requirement of 37 C.F.R. §1.178, Applicant hereby offers to surrender the original patent, U.S. Patent No. 5,646,733, issued on July 8, 1997, to Leonard H. Bieman, and entitled "SCANNING PHASE MEASURING METHOD AND SYSTEM FOR AN OBJECT AT A VISION STATION,", or, if the original is lost or inaccessible, an affidavit to such effect will be supplied before allowance of the above-identified reissue application.

Respectfully submitted,

By their Representatives,

SCHWEGMAN, LUNDBERG, WOESSNER & KLUTH, P.A.
P.O. Box 2938
Minneapolis, MN 55402
(612) 373-6949

Date 8 July 1998 By Charles A. Lemaire

Charles A. Lemaire
Reg. No. 36,198

"Express Mail" mailing label number: EM287849544US

Date of Deposit: July 8, 1998

I hereby certify that this paper or fee is being deposited with the United States Postal Service " Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231

Printed Name Charles A. Lemaire

Signature Charles A Lemaire

REISSUE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Leonard H. Bieman	Examiner: Unknown
Serial No.:	Unknown	Group Art Unit: Unknown
Filed:	Herewith	Docket: 139.032USR
Title:	SCANNING PHASE MEASURING METHOD AND SYSTEM FOR AN OBJECT AT A VISION STATION	

**ASSENT BY ASSIGNEE UNDER 37 C.F.R.§1.172
AND POWER OF ATTORNEY**

BOX PATENT APPLICATION
Assistant Commissioner for Patents
Washington, D.C. 20231

PPT Vision, Inc., being the Assignee of the entire interest in and to U.S. Patent No. 5,646,733, issued on July 8, 1997, to Leonard Bieman, and entitled "SCANNING PHASE MEASURING METHOD AND SYSTEM FOR AN OBJECT AT A VISION STATION,", hereby assents to the reissue of said patent.

Assignee hereby appoints:

Anglin, J. Michael	Reg. No. 24,916
Bianchi, Timothy E.	Reg. No. 39,610
Billion, Richard E.	Reg. No. 32,836
Brennan, Thomas F.	Reg. No. 35,075
Brooks, Edward J., III	Reg. No. 40,925
Clark, Barbara J.	Reg. No. 38,107
Drake, Eduardo E.	Reg. No. 40,594
Dryja, Michael A.	Reg. No. 39,662
Embretson, Janet E.	Reg. No. 39,665
Fogg, David N.	Reg. No. 35,138
Forrest, Bradley A.	Reg. No. 30,837
Hale, Jeffrey D.	Reg. No. 40,012
Harris, Robert J.	Reg. No. 37,346
Hofmann, Rudolph P., Jr.	Reg. No. 38,187
Holloway, Sheryl S.	Reg. No. 37,850
Kalis, Janal M.	Reg. No. 37,650
Klima-Silberg, Catherine I.	Reg. No. 40,052
Kluth, Daniel J.	Reg. No. 32,146
Lacy, Rodney L.	Reg. No. 41,136
Leffert, Thomas W.	Reg. No. 40,697
Lemaire, Charles A.	Reg. No. 36,198
Litman, Mark A.	Reg. No. 26,390
Lundberg, Steven W.	Reg. No. 30,568
McCrackin, Ann M.	Reg. No. P-42,858
Polglaze, Daniel J.	Reg. No. 39,801
Schwegman, Micheal L.	Reg. No. 25,816
Sieffert, Kent J.	Reg. No. 41,312

Slifer, Russell D.	Reg. No. 39,838
Terry, Kathleen R.	Reg. No. 31,884
Viksnins, Ann S.	Reg. No. 37,748
Woessner, Warren D.	Reg. No. 30,440

as its attorneys, with full power of substitution and revocation, to prosecute the reissue application, to make alterations and amendments therein, and to transact all business in the U.S. Patent and Trademark Office in connection therewith, and to receive the Letters Patent. Please direct all communications to the following:

Charles A. Lemaire, Esq.
Schwegman, Lundberg, Woessner & Kluth, P.A.
1600 TCF Tower
121 South Eight Street
Minneapolis, MN 55402
(612) 373-6949

CERTIFICATE UNDER 37 C.F.R. §3.73(b)

PPT Vision, Inc. hereby certifies that it is the assignee of the entire right, title, and interest in U.S. Patent No. 5,646,733 identified above by virtue of an assignment from Medar, Inc. to PPT Vision, Inc., filed in the patent application and recorded on Reel (   ), Frame (   ), which right, title, and interest was transferred from the inventor to Medar Inc., as recorded on Reel 7857, Frame 0746. To the best of my knowledge and belief, title is in the assignee, PPT Vision, Inc.

Pursuant to 37 C.F.R. §3.73(b) I hereby declare that I am empowered to sign this certificate on behalf of the assignee, PPT Vision, Inc.

I hereby declare that all statement made herein of my own knowledge are true, and that all statements made on information and belief are believed to true.

Date: 7/8/98 By: Joseph C. Christenson
Title: PRESIDENT

"Express Mail" mailing label number: EM 287 849 544 US

Date of Deposit: 8 July 1998

I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231

Printed Name Charles A. Lemaire

Signature Charles A Lemaire